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AUTHOR Tomera, Audrey N.; And Others
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ABSTRACT

Samples of professional scientists, science teachers, and preservice elementary education majors were sent a questionnaire consisting of the POSSI (Perceptions of Science and the Scientist Inventory) instrument. The instrument comprised six short-answer questions dealing with: (1) a definition of science, (2) the difference between science and technology, (3) the greatest contribution of science to man's culture, (4) the most important intellectual process to the scientist, (5) the paramount ethical responsibility of the scientist, and (6) the value of science education to human beings. Included in this report are analyses of the various types of answers given to these questions and the percentage of each sample group that responded with each answer-type. In general, the results of the study show that scientists and science educators have similar perceptions of science but that the preservice elementary education majors often had no response to questions or held views contrary to the scientists and science educators. (MH)

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A COMPARISON AND ANALYSIS OF CONCEPTS OF SCIENCE AND THE SCIENTIST HELD BY PROFESSIONAL SCIENTISTS, SCIENCE EDUCATORS, AND PRESERVICE ELEMENTARY EDUCATION MAJORS

Audrey N. Tomera
Science Education
Southern Illinois Univ.
Carbondale, Illinois
62901

Harold R. Hungerford
Science Education
Southern Illinois Univ.
Carbondale, Illinois
62901

Henry G. Walding
Science Education
Lewis-Clark College
Lewiston, Idaho
83501

Introduction

Over the last two decades, a good deal of research interest has been directed toward an analysis of the concepts and/or attitudes held by various populations concerning science and the scientist. These studies include those by Mead and Metraux (1957), Jungwirth (1974), and Walding and Hungerford (1974). Also, a great deal of instrument construction time has been invested in attempting to measure these desired concepts and/or attitudes.

With respect to the particular questions under investigation here and elsewhere, the researchers can find reference to no research which attempts to compare across the populations being compared in this study, i.e., professional scientists, science educators, and preservice elementary education majors.

The research questions appropriate to this investigation are:

Subsequent to analyses, do concepts held concerning science and the scientist differ across samples represented by professional scientists, science educators, and preservice elementary education majors for the components of . . .

1. . . . a definition of science?
2. . . . the difference between science and technology?
3. . . . the greatest contribution of science to man's culture.
4. . . . the most important intellectual process to the scientist?
5. . . . the paramount ethical responsibility of the scientist?
6. . . . the value of science education to human beings?

Although these six categories limit the breadth of the research, some serious educational and social issues are reflected therein. Among these is the inherent liability imposed on science education itself as a function of the professionals in this field who are largely responsible for the direction the discipline is taking. Are these directions philosophically sound with respect to the substantive structure of the sciences themselves. How, in reality, do science educators' perspective of science and the scientist

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compare to those of professional scientists? Are there implications for researchers who continue to attempt to objectively measure these and other concepts of and/or attitudes toward science and the scientist?

Do concepts held by undergraduates in elementary education compare favorably with those of the scientist? The science educator? If not, what are the implications for teacher education? For science experiences preceding teacher education, i.e., in elementary and secondary schools?

With recent social criticism of science per se, what are the socio-cultural responsibilities of scientists and the scientific community as perceived by scientists, science educators, and preservice elementary education majors? Are there differences in perception? If differences exist, what might account for them? What are the implications - both socially and educationally?

Instrumentation

Irrespective of the intellectual domain (i.e., cognitive or affective)[1] specified by the researchers as the focus of the research, a distinct problem exists in developing instruments for measuring cognitive and/or affective variables in this area of interest. Attempts have been made at developing instruments which would empirically assess both attitudes and concepts. Instruments have ranged from open-ended phenomenological ones (Mead and Metraux, 1957; Hungerford, 1972; Lowery, 1966) to Likert-type scales (Cummings, 1970; Motz, 1971) to multiple choice standardized instruments (Cooley and Klopfer, 1961). Serious problems have arisen with at least some of these instruments when researchers have attempted to establish construct validity with respect to the philosophy of science held by scientist themselves. These problems have been reflected by Allen (1959) and by Jungwirth (1974).

Jungwirth (1974), in a study dealing with instrument analysis, attempted to validate the Test On Understanding Science (Cooley and Klopfer, 1961) by comparing discrete test items against opinions held by a panel of university scientists. In commenting on said validity, he writes . . .

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[1]A review of the literature indicates, that both human perceptions of and attitudes toward science and the scientist have been researched. An indepth investigation of these research studies also reveals that the researchers have not always been careful in distinguishing between attitudes held on one hand and concepts on the other. A pertinent reference to this confusion is made by Jungwirth (1974) when he writes . . .

> Evaluating pupils' understanding of science is a borderline case in curriculum evaluation. There seems to be some difficulty in deciding which domain (cognitive or affective) is the right address. I have always held that whenever 'understanding' is concerned, the matter belong to the cognitive domain. However, this view is not universally held . . . . The use of the terms 'appreciation' and 'recognition' in lieu of 'understanding' appears to be highly arbitrary.

" . . . assessing pupil achievement in 'understanding the nature of science' is hampered by several difficulties. A group of university professors was used in order to illustrate these difficulties. I have shown that divergent responses, that is, responses not compatible with the views held by the test authors, may originate in bona fide differences of opinion with the domain of the philosophy of science, and also in misguided linguistic analyses. It would be belaboring the obvious to state that test reliability without test validity is meaningless. TOUS's overall validity, again taking the professors as the criterion, seems to be reasonably high, but the validity of some of the items is doubtful, both on philosophical and semantic grounds."

The question of instrumentation is raised here, not as an adjunct to the discussion, but as a critical element. Instrumentation is, indeed, a key to the validity of studies dealing with topics in question. Science educators seem prone to assume that certain professional science experiences or competencies possessed by scientists will reflect themselves in the validation of instruments which can be used in assessing the attitudes and/or concepts of students concerning science and the scientist. However, those intuitive assumptions have not been shown to be empirically valid across those studies investigating same. Such difficulties have been encountered by Pickering (1970), Barrets (1970), and Terrance (1967).

The question, then, becomes one of the potential for doing research in this area as well as the significance of the research. Although the inherent limitations of phenomenological research are acknowledged by the writers, it appears as though this mode of data collection is pertinent to this topic.

For the past several years, a phenomenological instrument has been used by the writers for measuring perceptions of science and the scientist (Hungerford, 1972; Walding and Hungerford, 1973). It will be hereafter refered to as the POSSI instrument (Perceptions of Science and the Scientist Inventory). Not only does this instrument seem to hold considersble promise for measuring some of the cognitive variables in question, but it has also been found very effective in measuring changes in perception as a function of instruction (Walding and Hungerford, 1974). This latter observation also positively impinges on the validity of the POSSI instrument, supporting its use in a study such as this.

The POSSI instrument used in this research can be found in Appendix A.

One of the prominent criticisms leveled against an open-ended type of an instrument rests with scoring problems. Can the responses be interpreted? Can interscorer reliability for the instrument be demonstrated?

The instrument used in this study was first used in 1967 to assess concepts held by secondary school students when they completed an instructional module dealing with the characteristics of science and the scientist. It was redesigned for use with science methods students at Southern Illinois University-Carbondale in 1971. Interscorer reliability was intuitively assumed until 1976. At this time, three science educators at SIU-C, trained to score the POSSI instrument, independently scored 34 instruments completed by elementary science methods students. The results of this analysis can be found in Table I. There appears to be substantial interscorer reliability associated

with the instrument as reflected by the X^2 value for each question.

Table I

Interscorer Reliability for POSSI Assessment Instrument* - Three Scorers, 34 Respondents

Item	X^2 Value**	X^2 Critical at .10	df (r-1) (c-1)=df	S/NS***
1	2.535	7.78	(2) (2) = 4	N.S.
2	3.435	10.64	(2) (3) = 6	N.S.
3	5.520	23.54	(2) (8) = 16	N.S.
4	3.456	18.55	(2) (6) = 12	N.S.
5	7.607	21.06	(2) (7) = 14	N.S.

* - All tests were preservice ele. educ. majors' responses

r = 3 scorers

c = number of response categories

** - Chi-Square value obtained.

*** - Significant or Not Significant

The categories chosen for responses for each question have been derived from the hundreds of responses collected over the years during which this instrument has been used. It has been found that categories tend to remain stable over time. However, when a response does dictate a new category that new category is generated.

What follows is a complete listing of all categories utilized for each question in this study. Hereafter, certain categories will be collapsed to facilitate data reporting and they will also be abbreviated in an effort to conserve space in the tables where they are reported.

Response Categories for Question 1: If you were asked to define science how would you do it? Please complete the following: Science is . . .

Categories:

1. A response alluding to a combination of process and product OR a generic statement implying this, e.g., a method of studying objects and/or events, empiricism, a logical means of investigating the universe.

2. A response alluding simply to a "study of" objects and/or events without any qualifying statement as to the nature of that study, e.g., exploration of the world, the study of man or the environment.

3. A response alluding to a "discovery phenomenon", e.g. the discovery of living and/or nonliving things or information about the environment.

4. A response alluding to a specific mode of study other than empiricism per se, e.g., hypothesizing, theorizing, prediction.

5. Responses alluding to the knowledge component of science per se. Either as knowledge about objects and/or events or a broad field of study - a content area.

6. A response which tends to equate science with objects and/or events. Science as synonymous with objects and/or events.

7. Respondent did not know and so stated, or item was left blank.

8. A response which was ambiguous and could not be interpreted or categorized logically, e.g., a dialogue with nature; things that one can explore, take apart or add on to; asking questions and seeking answers; a method of learning.

Response Categories for Question 2: If you were asked to state how science and technology differ, how would you answer? Please do so below: Science and technology differ . . .

Categories:

1. Response alluding to science as a process providing information whereas technology is the application of that knowledge.

2. Responses alluding to science as a process (or research) whereas technology is invention or the creation of objects.

3. Responses alluding to technology as a component part of science . . . or, a subscience . . . or, a field within science.

4. Responses alluding to science and technology as being synonymous.

5. Responses which equate science with objects and/or events and technology as a "man-made" venture.

6. Responses which allude to technology as something which is utilized in the doing of science per se.

7. Respondent did not know and so stated, or item was left blank.

8. A response which was ambiguous and could not be interpreted or categorized logically, e.g., is in that technology is more specific and specialized, while science is rather broad; . . . to the degree that they are similar and dissimilar according to their usage; . . . differ in long range perspectives.

Response Categories for Question 3: If you were asked to tell someone what you felt the one greatest contribution was that science has made to man's culture, what would you say? The greatest contribution of science is . . .

Categories

1. A response alluding to some aspect of scientific method, empiricism, or logical thinking.

2. A response alluding to some medical application, e.g. control of disease, drugs.

3. A response alluding to the development of a specific theory, e.g., the germ theory, evolution.

4. A response alluding to a specific scientific milestone other than theories, e.g., the discovery of fire, splitting the atom.

5. Responses which allude to some component of man's ability to control his environment. Not milestones or theories per se, e.g., food production, transportation.

6. Responses which allude to man's understanding of self and/or the environment, e.g., to help humans find out information to improve their culture.

7. Respondent stated that there was no one greatest contribution.

8. Respondent did not know and so stated, or item was left blank.

9. A response which was ambiguous and could not be interpreted or categorized logically, e.g, . . . life made easy; . . . hope, the belief that we can find answers; . . . opening the door to the real beauty of nature; . . . increased communication.

Response Categories for Question No. 4: A scientist usually has to use both manipulative and intellectual skills (processes) in his work. What one intellectual skill do you think is the most important to a scientist?

Categories:

1. Responses alluding generally to the ability to reason, think abstractly or to use critical thinking.

2. Responses alluding to the ability to inquire or to apply knowledge and reasoning.

3. Experimentation. 4. Observation. 5. Hypothesizing.

6. Theorizing. 7. Inferring. 8. Mathematics.

9. All other discrete processes, e.g., classification, drawing conclusions.

10. Responses which allude to creativity and/or imagination.

11. Responses alluding to some element of affect (attitude) and not process.

12. Respondent did not know and so stated, or item was left blank.

13. A response which was ambiguous and could not be interpreted or categorized logically, e.g., . . . integration at the critical level; . . . contemplation; . . . intellectual ballet.

Response Categories for Question No. 5: A scientist, working as a scientist, must have at least one ethical responsibility. What ethical responsibility do you see as paramount in a scientist's profession?

Categories:

1. A response which alludes to altruism, e.g., to work for the betterment of mankind.

2. Responses which are general in that they may or may not indicate altruism, e.g., to have regard for the well-being and safety of life, to better the world, to insure that contributions are not used in a harmful way.

3. Responses that allude to empiricism, per se, e.g., intellectual honesty.

4. Responses alluding to making sure that the scientist is not trying to play God.

5. Responses alluding to the need to communicate findings to the rest of the world.

6. Responses alluding to persistance.

7. Responses alluding to the need to guard against plagiarism.

8. Respondent did not know and so stated, or item was left blank.

9. A response which was ambiguous and could not be interpreted or categorized logically, e.g, . . . none; . . . being true to ourselves and others; . . . responsibility to educate public on what is science.

Response Categories for Question No. 6: If science is a part of the general education of human beings, it must have some value to them. Of what value is science education to human beings? Please name one value.

Categories:

1. Responses alluding to components of critical thinking, e.g., critical thinking per se, reasoning, logical thinking.

2. Responses alluding to adjustment potential, e.g., reducing fear and superstition.

3. Responses alluding to survival potential for man; awareness of critical problems and solutions to those problems.

4. Responses alluding to man better understanding his environment and the world around him.

5. Responses alluding to man better understanding himself.

6. Responses alluding to man being able to enjoy a better, richer, fuller life.

7. Responses alluding to man gaining new information , i.e. knowledge.

8. Responses alluding to the enjoyment and/or appreciation of science.

9. Respondent did not know and so stated, or item was left blank.

10. A response which was ambiguous and could not be interpreted or categorized logically, e.g., . . . a world view; . . . no real value to 98% of our citizens; . . . analysis of values; . . . the division between "general education" and science education is inappropriate.

Samples and Associated Research Validity Concerns

Three populations were sampled in this research. These were:

1. Professional scientists, N=70
2. Science educators, N=148
3. Preservice elementary education majors, N=105

Professional scientists were sampled in two separate ways. Samples of convenience were utilized with mailings to associates in a number of science departments at SIU-C, the Illinois Natural History Survey, Jackson State University (Mississippi), and the Idaho Academy of Science. These scientists represented a wide cross-section of science disciplines, e.g. physics, faunistics, geology, zoology, and others.

A separate mailing to 165 scientists was sent to five representative institutions of higher learning in the United States, selected by the researcher, i.e. Purdue University, Cornell University, University of Iowa, University of Missouri, and the University of Chicago. The researchers randomly chose scientists in the science departments of these institutions. Care was taken to choose scientists from a wide variety of disciplines. An effort was made that no scientist was used who was cross-appointed to science education.

The rate of return from the combined strategies was under 25%. This low rate of return is of concern to the writers for a number of reasons. Among these is the question of whether the instrument was presented in a manner as to stimulate a low return from this population. A second concern is whether the items themselves were such as to prompt returns only from those scientists who felt comfortable with the topics in question. If

this should be the case there is a serious external validity questions associated with the results.

Science educators were sampled with the cooperation of the Association for the Education of Teachers of Science which made its mailing list available to the researchers. Even though return postage was not included in this mailing, the rate of return was high - in excess of 40%. It appears quite probable that this population felt much more comfortable on the whole with the topics in question than did the professional scientists.

The sample of preservice elementary education majors was obtained at SIU-C. The science methods students were assessed at the beginning of the required science methods course for junior and senior undergraduates. None had prior training in science education methods.

The researchers had hoped that the SIU-C sample would represent junior and senior undergraduates in elementary education as an overall population. However, it must be noted that a subsequent unpublished pilot investigation conducted by Henry C. Frazier of Jackson State University in Jackson, Mississippi (1976) indicates that the SIU-C sample is not truly representative of this particular population. When compared to a similar sample from southern emerging institutions it was found that the SIU-C sample was considerably more responsive with respect to this instrument than the southern counterpart. Therefore, the researchers once again feel some concern about the external validity of this research. The results from elementary education undergraduates can be generalized, at best, only to institutions similar to SIU-C, i.e., institutions which do not represent those with "emerging" status.

Findings with Comments

The results of this assessment can be found in Tables II-VII. In each case, the raw score for each response has been reported as a percentage for each population, i.e., scientists, science educators, and elementary education majors. The resultant graph permits the reader to quickly conceptualize individual response patterns for all six instrument items.

In a few instances, the researchers found it necessary to collapse two or more responses into one, more generic response. This was done solely to facilitate reporting and interpretation. Such was the case, for example, in Question Six (6), the second response category. Originally, responses had been categorized into two separate categories instead of the one found in the table, i.e., (a) adjustment and, (b) survival potential.

In most cases - but not all - the predominant response is No. 1 in the table. However, as can be observed in the graphs, the numbering system for the categories is not rank ordered according to the percentages. In all cases, the last two categories represent ambiguous responses and responses in which the respondent did not know (or blank responses).

Question 1 - A Definition of Science (Table II): The results of this research with respect to Question 1 are probably consistent with what one might expect with one notable exception. Both scientists and science educators tended to define science in a manner that reflected an appropriate understanding of that enterprise as perceived by the authors of this report, i.e. a definition that identified both the "process" and "product" components of science. Preservice teachers, however, tend to communicate their perspectives of science in a very generalized manner, perhaps because they are unsure of its exact parameters. This tends to be substantiated, in part, by their responses to Question 2. Of considerable concern to the researchers is why science educators provided over 16% ambiguous responses to Question 1. The reason for this phenomenon is not at all clear.

Question 2 - The Difference Between Science and Technology (Table III): Both scientists and science educators appear to possess a clear concept of technology as it is related to science. Preservice elementary education majors, however, tend to demonstrate a confused and often erroneous concept of technology as it relates to science. Only 1 in 4 presented what was perceived by the researchers to be a suitable response (No. 1) while 50% of the preservice teachers either had no idea of a correct response or responded ambiguously.

Question 3 - The Greatest Contribution of Science (Table IV): The responses to this item are very interesting and provide considerable enlightenment to the researchers.

As expected, preservice teachers often felt the greatest contribution to be in the area of medicine. Very few of the preservice teachers, however, perceived empiricism to be the greatest contribution while over 25% of the scientists and 51% of the science educators did. Although these are both substantial percentages, the researchers wonder why twice as many science educators perceive empiricism as the greatest contribution than do scientists themselves. Could it be that science educators are more interested in the philosophical dimensions of science than are scientists?

All populations were represented by numerous individuals who felt that knowledge of self and/or the environment constitutes the greatest contribution.

It is significant that over 25% of the preservice teachers failed to respond to the question or responded in a manner so ambiguous as to defy categorization.

Question 4 - Intellectual Skills Most Important to a Scientist (Table V): By virtue of the diversity of response and the nature of the greatest single category, there must be some concern raised about the validity of this item. Over 41% of the scientists and 31% of the science educators responded with generic statements dealing with "reasoning," "logical thinking," etc. These descriptors are not discrete intellectual skills. Other responses covered a wide range of categories with no single one standing out sharply with the exception, perhaps, of observation (No. 4). Again, nearly 1 in 3 of the preservice teachers did not know or provided an ambiguous response.

TABLE II

Percentages by Respondents - Question 1

Q. 1. If you were asked to define science, how would you do it? Science is . . .

All Response Categories	Samples	0 10 20 30 40 50 60 70 80 90 100	Percentages
1. Response alluding to both process & product - Empiricism	P.S.*	==========	61.43
	S.E.	==========	59.18
	E.E.	======	9.52
2. A study of objects and/or events, no reference to process	P.S.	==========	22.86
	S.E.	==========	17.01
	E.E.	==========	63.81
3. Discovery phenomenon	P.S.	=	1.43
	S.E.	=	1.36
	E.E.	=	.95
4. A specific process or combination of processes	P.S.	==	1.43
	S.E.	====	4.08
	E.E.	=====	6.66
5. Knowledge per se.	P.S.	=====	7.14
	S.E.	=	.68
	E.E.	====	6.66
6. Equating science with objects and events	P.S.		0.00
	S.E.	=	1.36
	E.E.	==	2.86
7. Respondent did not know - or item blank	P.S.		0.00
	S.E.		0.00
	E.E.	===	3.82
8. Ambiguous - could not interpret	P.S.	===	5.71
	S.E.	==========	16.33
	E.E.	====	5.72

*P.S. - Professional Scientists (N=70)
S.E. - Science Educators (N-148)
E.E. - Preservice Elementary Education Majors (N=105)

TABLE III

Percentages by Respondents - Question 2

Q. 2. State how science and technology differ.

All Response Categories	Samples	0 10 20 30 40 50 60 70 80 90 100	Percentages
1. Science as a process; technology as application of scientific knowledge	P.S.*	▬▬▬

TABLE IV

Percentages by Respondents - Question 3

Q. 3. The greatest contribution of science to man's culture is?

All Response Categories	Samples	0 10 20 30 40 50 60 70 80 90 100	Percentages
1. Empiricism, logical methods or thinking, scientific method, etc.	P.S.*	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	25.71
	S.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	51.03
	E.E.	▬▬	2.86
2. Some medical application	P.S.*	▬▬▬▬	7.15
	S.E.	▬	.68
	E.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	35.24
3. Theories or science milestones other than theories, e.g. (splitting the atom)	P.S.*	▬▬▬▬▬	7.14
	S.E.	▬▬▬▬▬▬	8.16
	E.E.	▬▬▬▬▬▬▬	10.27
4. Man's ability to control the environment in some way	P.S.*	▬▬▬▬▬▬▬	10.00
	S.E.	▬▬▬	3.40
	E.E.	▬▬	2.86
5. An understanding of self and/or the environment	P.S.*	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	27.14
	S.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	21.09
	E.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	17.14
6. Respondent stated that there was no one greatest contribution	P.S.*	▬▬▬▬▬▬▬	10.00
	S.E.	▬	1.36
	E.E.	▬▬▬▬▬	5.72
7. Respondent did not know-or item blank	P.S.*	▬▬▬▬▬	7.15
	S.E.	▬▬	3.40
	E.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	15.24
8. Ambiguous - could not interpret	P.S.*	▬▬▬▬▬	5.71
	S.E.	▬▬▬▬▬▬▬▬	10.88
	E.E.	▬▬▬▬▬▬▬▬	10.48

*P.S. - Professional Scientists (N=70)
S.E. - Science Educators (N=148)
E.E. - Preservice Elementary Education Majors (N=105)

TABLE V

Percentages by Respondents - Question 4

Q. 4. What one intellectual process (skill) is most important to a scientist?

All Response Categories	Sample	0 10 20 30 40 50 60 70 80 90 100	Percentages
1. To reason, logical thinking, to think abstractly.	P.S.*	==========	41.43
	S.E.	==========	31.96
	E.E.	==========	18.09
2. Ability to inquire, to research, to apply knowledge, etc.	P.S.*	=	1.43
	S.E.	==	2.03
	E.E.	==	2.86
3. Experimentation	P.S.*	=	1.43
	S.E.	====	4.75
	E.E.	====	4.76
4. Observation	P.S.*	====	4.28
	S.E.	========	10.20
	E.E.	======	6.66
5. Hypothesizing	P.S.*	=	1.43
	S.E.	======	6.80
	E.E.	==	2.86
6. Theorizing	P.S.*		0.00
	S.E.	==	2.03
	E.E.		0.00
7. Inferring	P.S.*	==	2.86
	S.E.	====	4.75
	E.E.	=	.95
8. Mathematics	P.S.*	===	4.28
	S.E.		0.00
	E.E.	=	1.90
9. Any other discrete processes	P.S.*	==	2.86
	S.E.	===	3.40
	E.E.	==========	15.24

* P.S. - Professional Scientists (N=70)
S.E. - Science Educators (N=148)
E.E. - Preservice Elementary Education Majors (N=105)

Question 4 (Continued)

All Response Categories	Samples	0 10 20 30 40 50 60 70 80 90 100	Percentages
10. Creativity-Imagination	P.S.*	▬▬▬	8.57
	S.E.	▬▬▬	6.12
	E.E.		0.00
11. Response alluding to attitude, not process	P.S.*	▬▬▬▬▬	12.86
	S.E.	▬▬▬▬	8.84
	E.E.	▬▬▬▬▬▬▬▬	18.10
12. Respondent did not know-or item blank	P.S.*	▬	1.43
	S.E.	▬	2.03
	E.E.	▬▬▬▬▬	12.38
13. Ambiguous-could not interpret	P.S.*	▬ ▬▬▬▬▬	17.14
	S.E.	▬▬▬▬▬▬▬	17.00
	E.E.	▬▬▬▬▬▬	16.19

TABLE VI

Percentages by Respondents - Question 5

Q. 5. What ethical responsibility do you see as paramount in a scientist's profession?

All Response Categories	Samples	0 10 20 30 40 50 60 70 80 90 100	Percentages
1. Empiricism, intellectual honesty, etc.	P.S.*	----------	64.29
	S.E.	----------	57.82
	E.E.	----------	17.14
2. Altruism or a general respect for life and the environment	P.S.*	----------	17.14
	S.E.	----------	25.86
	E.E.	----------	41.90
3. To guard against being plagiaristic	P.S.*		0.00
	S.E.	-	.68
	E.E.		0.00
4. Not to play God	P.S.*		0.00
	S.E.	-	.68
	E.E.		0.00
5. To communicate research findings to the world	P.S.*	------	7.14
	S.E.	-----	5.44
	E.E.	---	3.82
6. Persistence	P.S.*		0.00
	S.E.		0.00
	E.E.	-	.95
7. Respondent did not know-or item blank	P.S.*	-	1.43
	S.E.	-	1.36
	E.E.	----------	20.95
8. Ambiguous - could not interpret	P.S.*	-------	10.00
	S.E.	------	8.16
	E.E.	----------	15.24

*P.S. - Professional Scientists (N=70)
S.E. - Science Educators (N=148)
E.E. - Preservice Elementary Education Majors (N=105)

TABLE VII

Percentages by Respondents, Question 6

Q. 6. Of What value is science education to human beings?

All Response Categories	Samples	0 10 20 30 40 50 60 70 80 90 100	Percentages
1. Critical thinking, logic, reasoning, etc.	P.S.*	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	25.71
	S.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	41.89
	E.E.	▬▬▬▬▬▬	8.57
2. Adjustment or survival potential for man.	P.S.*	▬▬▬▬▬	7.14
	S.E.	▬▬▬▬	6.08
	E.E.	▬▬▬	4.76
3. Man better understanding himself and/or the environment	P.S.*	▬▬▬▬▬▬▬▬▬▬ ▬▬▬▬▬▬▬▬▬▬	32.86
	S.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	25.68
	E.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬▬	54.28
4. Gaining man a better, richer, and fuller life.	P.S.*	▬▬▬▬	5.71
	S.E.	▬▬	3.38
	E.E.	▬▬▬	4.76
5. Man gaining new knowledge	P.S.*	▬	1.43
	S.E.	▬▬▬▬	4.05
	E.E.	▬▬▬	4.76
6. Esthetics, enjoyment and/or appreciation of science	P.S.*	▬▬	2.86
	S.E.	▬▬▬▬	4.73
	E.E.	▬	.95
7. Respondent did not know - or item blank	P.S.*	▬▬	2.86
	S.E.	▬	.68
	E.E.	▬▬	2.86
8. Ambiguous - could not interpret	P.S.*	▬▬▬▬▬▬▬▬▬▬▬▬▬	21.43
	S.E.	▬▬▬▬▬▬▬▬▬▬▬	13.51
	E.E.	▬▬▬▬▬▬▬▬▬▬▬▬▬	19.05

*P.S. - Professional Scientists (N=70)
S.E. - Science Educators (N=148)
E.E. - Preservice Elementary Education Majors (N=105)

Question 5 - Ethical Responsibility of the Scientist (Table VI): With respect to this item, the first two response categories are extremely interesting. Far fewer professional scientists saw altruism as the major ethical consideration than either science educators or preservice teachers. In the category of "intellectual honesty - empiricism," nearly 65% of the scientists thusly responded along with over 57% of the science educators. Only about 17% of the preservice teachers saw this category as critical while nearly 42% of them perceived altruism as the primary ethical responsibility. Thus one observes a dramatic disparity between the ethical perspectives of scientists and preservice teachers (nonscientists).

Of major concern with Question 5 is the 36% of the preservice teachers who were unable to respond or responded ambiguously.

Discussion

With the exception of Question 3 (. . . the greatest contribution . . .), the results indicate that scientists and science educators have similar perceptions of science and the scientist but that these same perceptions represent a number of different conceptual categories, (see Tables II-VII).

The findings definitely lend support to the idea that it will always be difficult, at best, to validate an objective instrument concerning science and the scientist using the responses of these populations as a source of instrument validity. Further, the findings lend credence to the strategy used in this study - to assess concepts (and/or attitudes) subjectively and then utilize these findings to make comparisons to other populations in which the researcher is interested. In the opinion of the writers, this technique holds considerable promise for assessing concepts and/or attitudes across a wide spectrum of population types. Even though a great deal of ambiguity results from this mode of instrumentation, the results gathered in this study definitely indicate that such an instrument is sensitive enough to show striking differences across populations, e.g. between preservice teachers and science educators. It is, therefore, recommended that research time be invested in the development of subjective instruments that assess those variables which would shed light on the concepts and/or attitudes held by a wide variety of populations.

The responses of the 105 preservice elementary education majors at SIU-C (all juniors and seniors in teacher education) are of great concern to the researchers. In none of the response categories which attracted the most responses from scientists and science educators did the percent of preservice teachers' response differently. One might question this finding on the grounds that the preservice teachers could not articulate their responses. This criticism seems unjustified when one observes that when the preservice teachers responded to an item, their responses seemed little more ambiguous than those of the scientists and science educators. A larger percentage of preservice teachers, however, failed to respond to the question or flatly stated that they did not know.

The preservice teachers' responses, then, show striking dissimilarities when compared to the scientists and science educators. If one assumes a modicum of instrument and research validity, these findings should be of great concern to all science educators. One must realize that junior and senior undergraduates represent a fairly sophisticated segment of society as a whole. It is, therefore, eminently discouraging to find that members of this population either totally lack desirable concepts or possess concepts which often run counter to those held by scientists and science educators. Further, when one realizes that this is the populations which will be responsible for teaching the nation's youth, the ramifications are frightening.

This same concern was reflected in a pilot study conducted by Walding and Hungerford (1974) when, using the same instrument, they assessed concepts held by 49 SIU-C preservice elementary education majors both before and after a unit in a science methods course devoted principally to the characteristics of science and the scientist (Hungerford and Tomera, 1974). Results indicated dramatic changes in these concepts. Further these shifts were in a direction deemed appropriate by the researchers.

It appears valid, then, to assume that preservice elementary school teachers generally have no concepts, faulty concepts, or poorly articulated concepts concerning science and the scientist prior to science methods instruction in the characteristics of science and the scientist seems eminently appropriate.

In addition - and perhaps of even greater concern - is the hypothesis that many other segments of society would perform no better on this instrument if their concepts were assessed. The implications of this hypothesis would be both clear and of considerable concern were it shown to be empirically valid. Thus, the researchers urge the science education community to commit research efforts to this end and to take whatever steps are necessary to ameliorate the situation should such a strategy prove necessary.

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Appendix A

Perceptions of Science and the Scientist Inventory (POSSI)
(Abbreviated Version)

The following are short-answer questions. Please respond to each and every one to the very best of your ability. Brief responses will often be as appropriate as long, confusing statements. (Note: If you definitely do not know of an appropriate response to any of the following, please state, "I don't know.")

ITEM NO. 1 -- If you were asked to define <u>science</u> how would you do it? Please complete the following:

Science is . . .

ITEM NO. 2 -- If you were asked to state how <u>science</u> and <u>technology</u> differ, how would you answer? Please do so below:

Science and technology differ . . .

ITEM NO. 3 -- If you were asked to tell someone what you felt the ONE greatest contribution was that science had made to man's culture, what would you say?

The ONE greatest contribution of science is . . .

ITEM NO. 4 -- A scientist usually has to use both manipulative and intellectual skills (processes) in his work. What ONE intellectual skill do you think is the most important to a scientist?

ITEM NO. 5 -- A scientist, <u>working as a scientist</u>, must have at least one ethical responsibility. What ethical responsibility do you see as paramount in a scientist's profession? Please state that ethical responsibility below:

ITEM NO. 6 -- If science is a part of the general education of human beings, it must have some value to them. Of what VALUE is science education to human beings?

Please name one value of science education to human beings.